DESIGNING AND MAKING A 'HELPING HAND'

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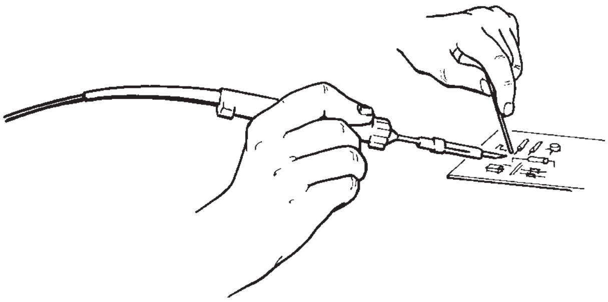
DESIGN BRIEF

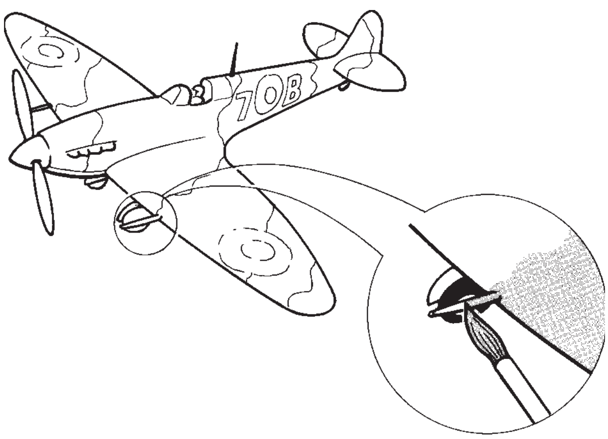
There are many occasions when it would be useful to have 'an extra pair of hands' .

The tasks you may wish to perform may be:

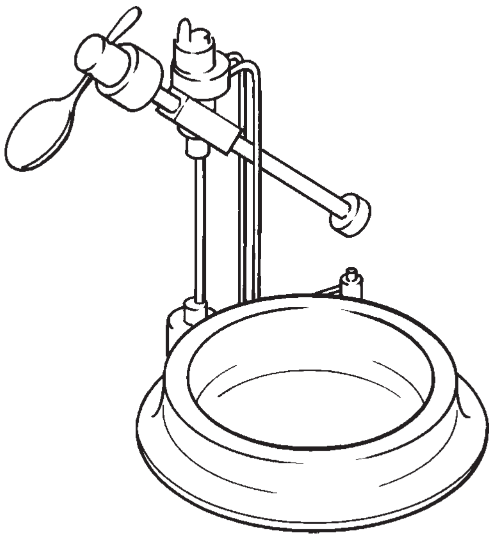
- holding a printed circuit board steady whilst soldering components in place



- using a magnifying lens to enhance the quality of completing an artefact, such as painting a model car or aircraft



- as an aid to everyday living for someone who is not able-bodied, to hold an item of cutlery



- other tasks you may think of ....

SPECIFICATION

First of all you need to draw up a specification for your 'helping hand'.

A specification is a more detailed description of what a product will be like, what it will do, and who will use it. The overall size of the holding unit, and the type and strength of materials you will need to use to build it from will be governed by the tasks the unit will have to perform. Will it be used:

- to grip heavy or light objects?

  How might this affect the stability of the unit, and might this have an influence upon the design of its base?

- will these objects be large or small, delicate, bulky or compact?

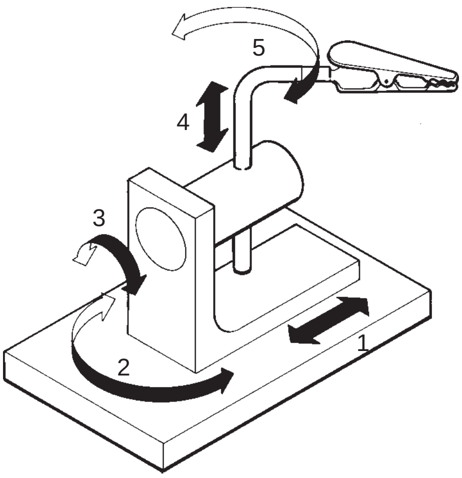
  How might this affect the shape and size of a gripper at the end of your unit?

- by someone who perhaps has limited strength in their fingers?

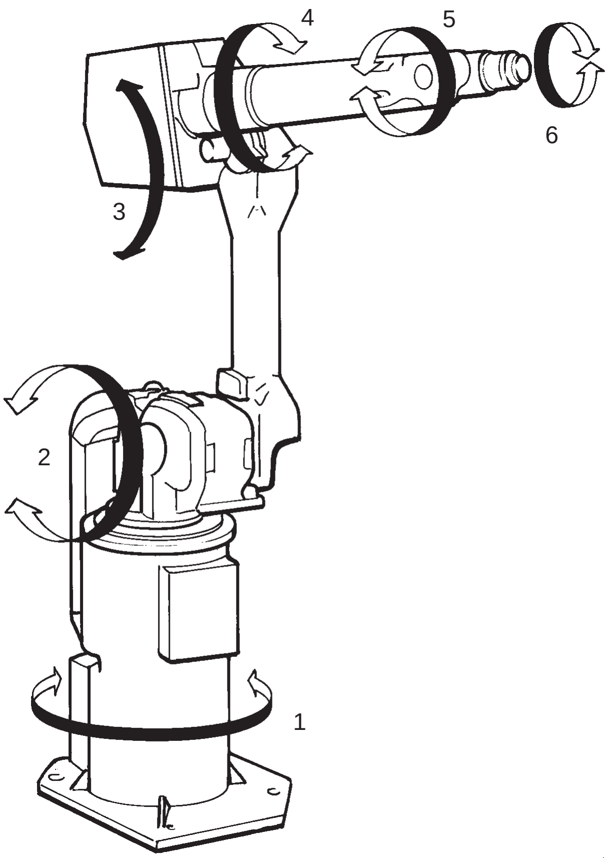
  How will you lock the various parts of unit in place so that it does not move whilst being used?

See Technology Study File 1: 'Design for Economic Manufacture and Assembly'

You will need to consider how the unit will be adjusted - how many directions it will need to move in order to give the required degree of precision of adjustment. It may well be that the unit you design and make will need to move in a total of 5 different ways



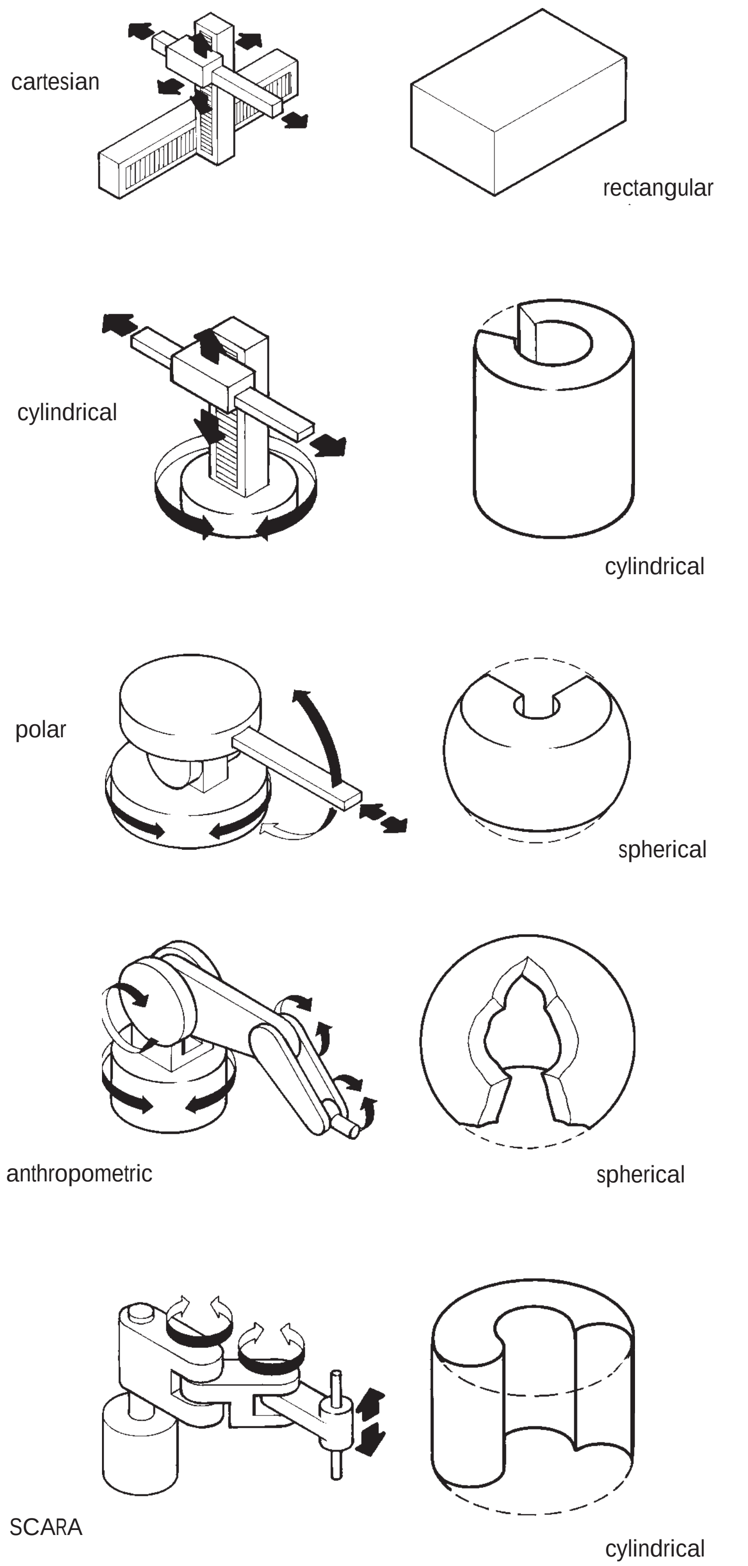
The versatility in the movement of your holding unit is an important consideration in the design of robots. The ways in which parts of robots move are called *degrees of freedom*. The most complex robot , an anthropomorphic robot, duplicates complete human arm movements. (Anthropomorphic means having human characteristics.) This robot has six degrees of freedom:



1. arm sweep - rotation about the base axis
2. shoulder swivel - rotation about the shoulder axis
3. elbow extension - rotation about the elbow axis
4. wrist pitch - up and down wrist movement
5. wrist yaw - side-to-side wrist movements
6. rotation about the wrist joint

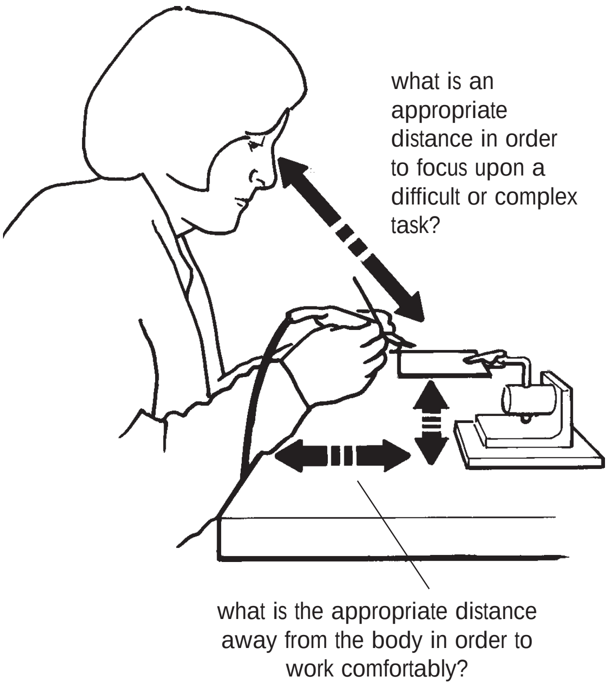
Degrees of arm freedom is important to robot work envelope. **Work envelope** is the area in which the robot can reach and work. An anthropomorphic robot has a spherical work envelope. Less complex robots with fewer degrees of freedom have work envelopes that are shaped like rectangles, cylinders or other shapes.

CONFIGURATION (Degrees of freedom) | **WORK ENVELOPE**



Think about the shape and size of the work envelope for your 'helping hand' Using a rule, measure and record:

- the vertical distance through which the 'helping hand' needs to be adjustable
- the horizontal distances through which the 'helping hand' needs to be adjustable (These distances may depend on whether you decide to clamp your holding device on to a table, or allow it to be free-standing.)



The ease of use of the unit will be governed by these factors. These are known as the ERGONOMIC CONSIDERATIONS - the interaction between the product and the user.

DESIGN CONSTRAINTS

Before you can take your design proposals very far, you will need to consider in some detail what materials and components are available to you. If you were a manufacturer intending to produce a large number of these units to sell in shops you would need to ask yourself the following questions:

Which parts of the 'helping hand' can I make?

- *do I know which materials I need?*

Are they fit for the job they have to do and are they available at a reasonable cost? How do I know that they are the most appropriate materials, and have I an idea of what a 'reasonable cost' is?

- *what is the simplest way that these parts can be made?*

- *do I have the necessary machine tools and equipment ?*

- *do I have the necessary skills to make these parts?*

- *how well made do these parts need to be made?*

Will this affect how many of these units I might sell? (Will making them to high degrees of accuracy make any difference to the cost of manufacture, the cost at which they might be sold, and therefore the profit? How can I ensure that the quality is good at every stage of the manufacturing process?)

- *how straightforward is it to assemble all the parts of the 'helping hand ' into its completed form?*

Estimate how long it might take to assemble one unit. Consider the costs associated with paying for this time (yours, or one of your workers if you were the owner of the manufacturing plant) compared to the costs of materials, and your selling price on to shops or wholesale suppliers.

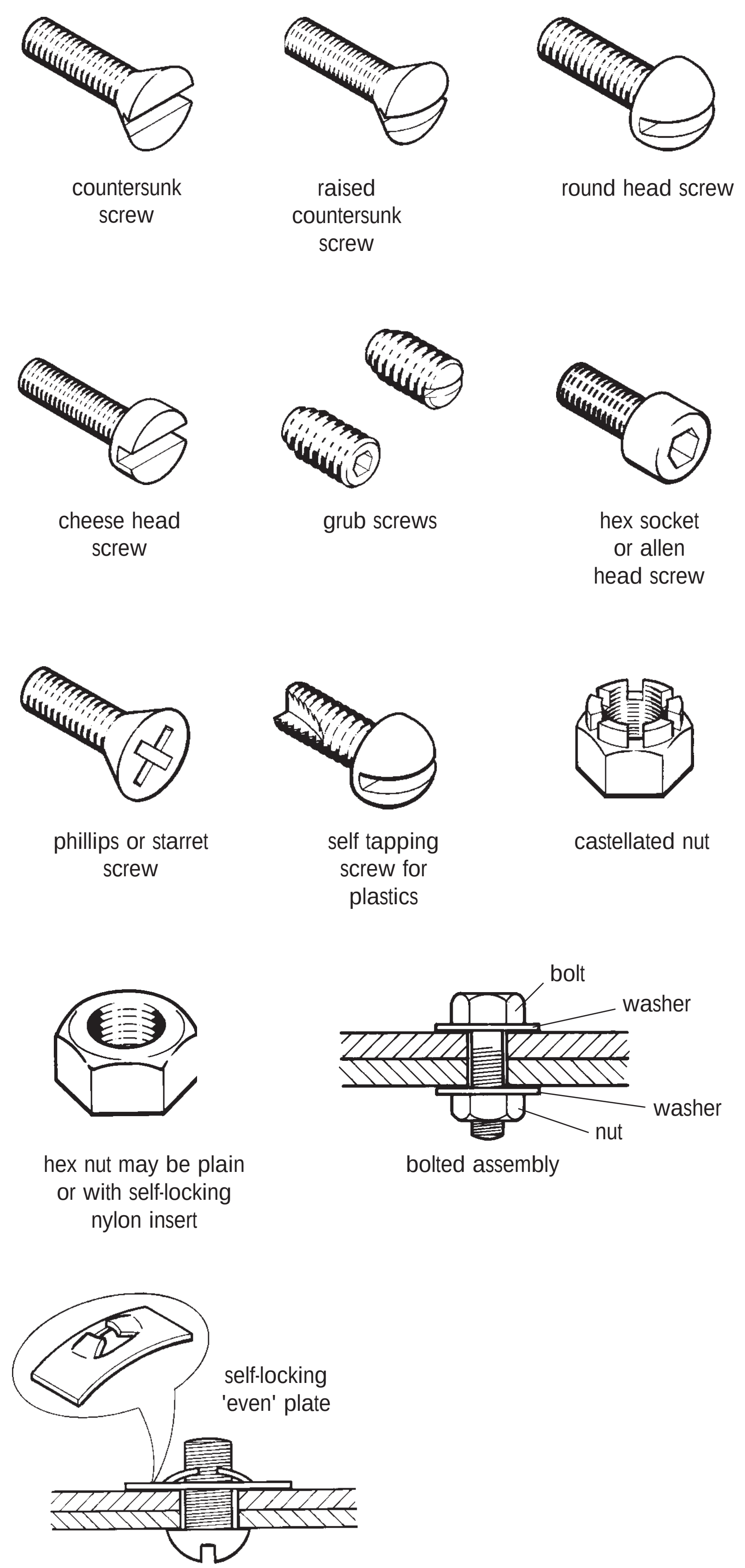
Which parts of the 'helping hand' can I buy?

- *are there several parts of the helping hand which are, or could be designed to be identical?*

How could you discover whether these parts are already made by other people? In a school or college situation, you are not in a position to pay other manufacturers to make parts of your product for you. Large manufacturing organisations may in fact make very few parts of the cars they sell themselves. They need to be very careful that these 'bought-in parts' from outside suppliers are made accurately and will give reliable service. If a part of the car fails through faulty manufacture, the customer will blame the car manufacturer, not the supplier.

Large manufacturing organisations use a variety of ways to ensure appropriate standards of quality. BS5750, the British Standard for Quality Systems, is concerned with the 'quality' assurance of the functional and organisational aspects of a company. As such it is very broad and comprehensive. It affects almost every part of an organisation - from planning and sales, to manufacture and maintenance. Companies need to demonstrate on a regular basis that they can meet these standards before they are able to say to potential customers that they are a BS5750-accredited organisation.

Types of fasteners



Now that most companies aim to trade world-wide the ISO (International Organisation for Standardisation) quality standard is another important quality assurance system. Manufacturing companies seek to attain ISO9001/9002 status as an important part of the their advertising and marketing strategies.

At school or college, the main 'bought-in' items are likely to be *fasteners* - nuts, bolts, machine screws, washers etc. As you design your holding device, try to use as few different sizes of fastener as possible - this should make part of the manufacturing process more straightforward, and therefore take less time - an important consideration if you were making these units to sell.

See Technology Study File 1: 'Design for Economic Manufacture and Assembly'

DESIGN PROPOSALS

There are three main areas for you to consider as you develop the designs for your 'helping hand'. They are:

1. ***the method of manufacturing the main supporting bracket for the unit***

2. ***the method of adjusting the parts of the unit, and how they will then be secured easily and accurately in place***

3. ***the 'gripping' or supporting device, at the end of the 'helping hand' unit***

1. Making the main support bracket

The main support bracket will need to carry the rest of the helping hand unit, together with whatever is being gripped - a magnifying glass, a printed circuit board etc. Depending upon the facilities that are available to you, you may decide to

- *cast the bracket*, by pouring molten metal (aluminium) into a mould

- *fabricate the bracket* - by joining several pieces of metal together, probably using heat

If you cast the bracket, a wooden replica, known as the pattern will need to be made first. The pattern:

- will need to be made slightly oversize, to allow for the contraction of the molten metal as it cools

- will need to be made slightly oversize, to allow for the contraction of the molten metal as it cools. For example:

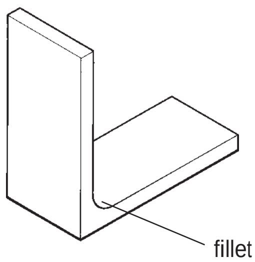
Cast iron will contract by approximately	0.8% per 30cm
Brass	1.6%
Steel	2.0%
Aluminium	2.8%

  Commercially, this contraction is allowed for by the patternmaker who uses a special rule called a *contraction rule*. For each metal the rule length is compensated for according to the contraction of the metal.

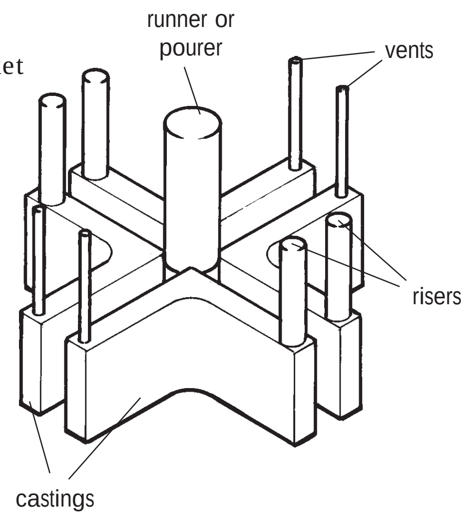
- be tapered to allow for its easy removal from the sand mould

- should not have any sharp internal corners, which could lead to faults or weakness at that point in the finished casting. The curve on the inside of the bracket is called a fillet

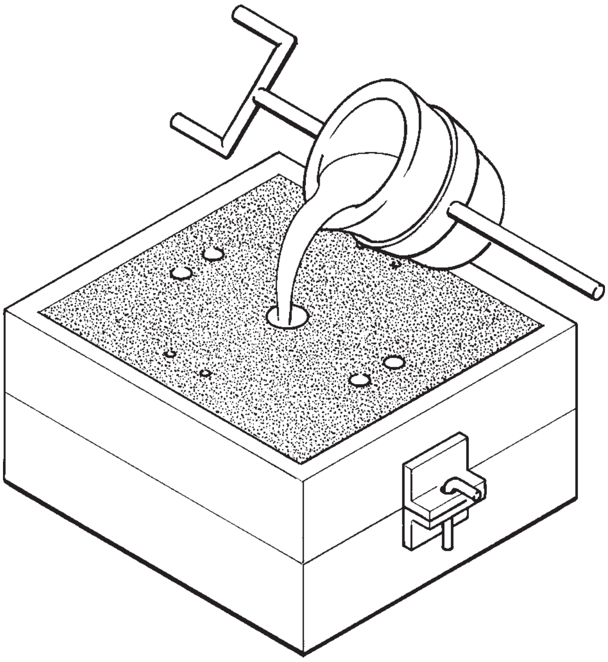
- be made carefully, with a smooth surface finish, as any faults or blemishes on the pattern will be reproduced on the metal casting

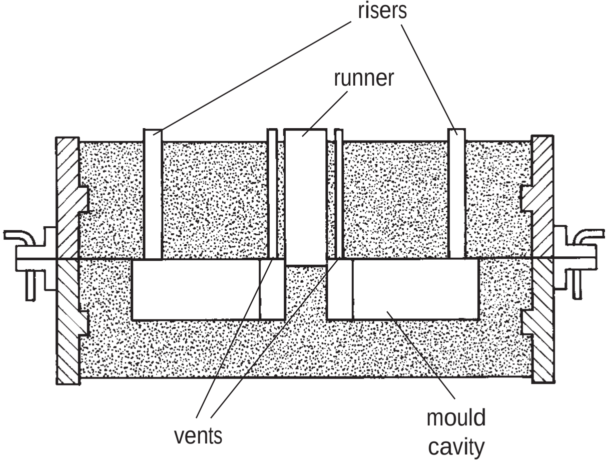


  It would not be a sensible use of time or energy (involved in melting the metal) to make these brackets one by one. It is possible to cast the bracket in 'trees' of three or four units at a time.

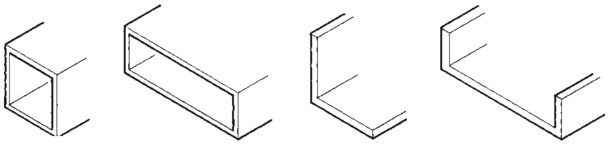


Notice that there is a central hole into which the molten aluminium is poured (known as the 'pourer') and a further hole at the end of each bracket. These holes are known as 'risers' and allow for the air trapped inside the mould cavity to escape as the metal is poured in. It should also indicate when the moulds are full, as the metal 'rises' up.

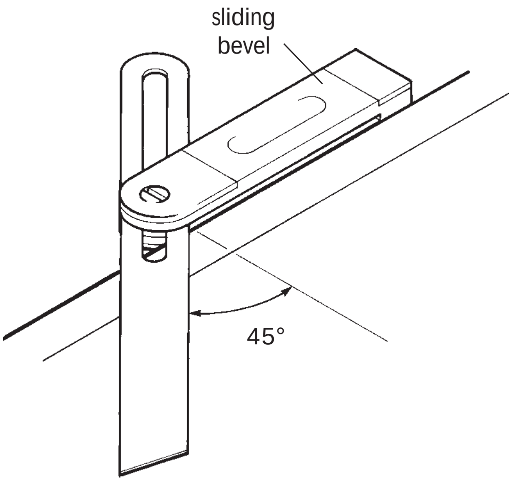




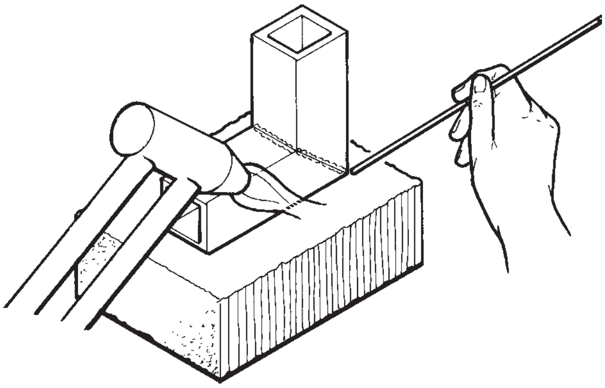
If you fabricate the bracket, then it is likely that you will use a metal *section* of material, which will be either square, rectangular or channel in shape.



As the bracket needs to be right-angled, you will need to mark out and cut the metal at 45 degrees. Ends of material shaped like this are called **mitres** - you will have seen them as part of picture frames. The mitres can be marked out using either a mitre square, or a sliding bevel set to 45 degrees.



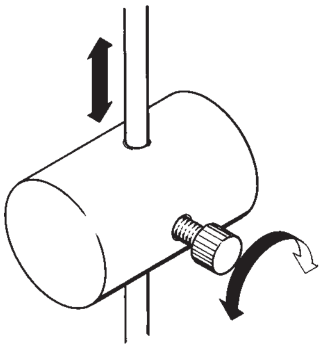
If you have used mild steel to make the bracket, the two parts can be joined using heat a brass-alloy filler rod known as *spelter,* using a process called *brazing.* A brazed joint is almost as strong as the mild steel itself.



2a. Methods of adjusting the parts of the unit

An important part of the specification is to allow for the 'helping hand' unit to be quickly and precisely secured in position. In order to do this, your unit may need to move in up to 5 different directions.

It is very straightforward to allow for movement, and adjustment in one direction only, by using a screw thread (see below).



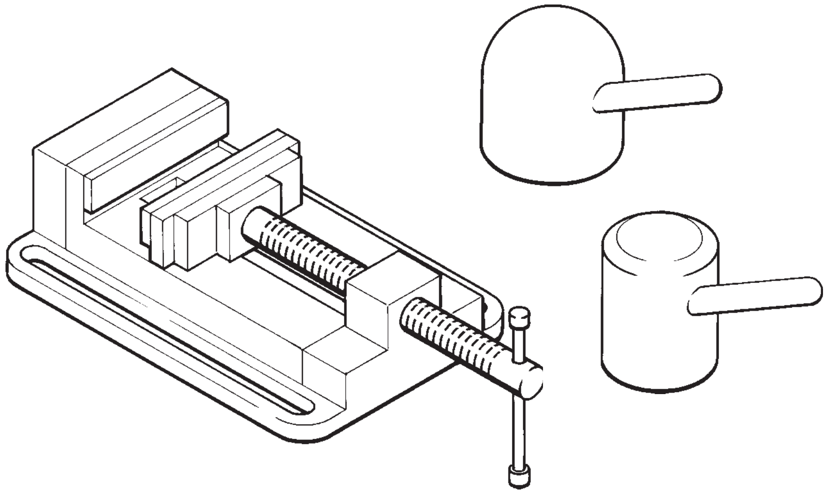
The design of the handle is important in terms of:

(a) the people who may use the unit, particularly if they have limited strength or manipulation in their fingers.

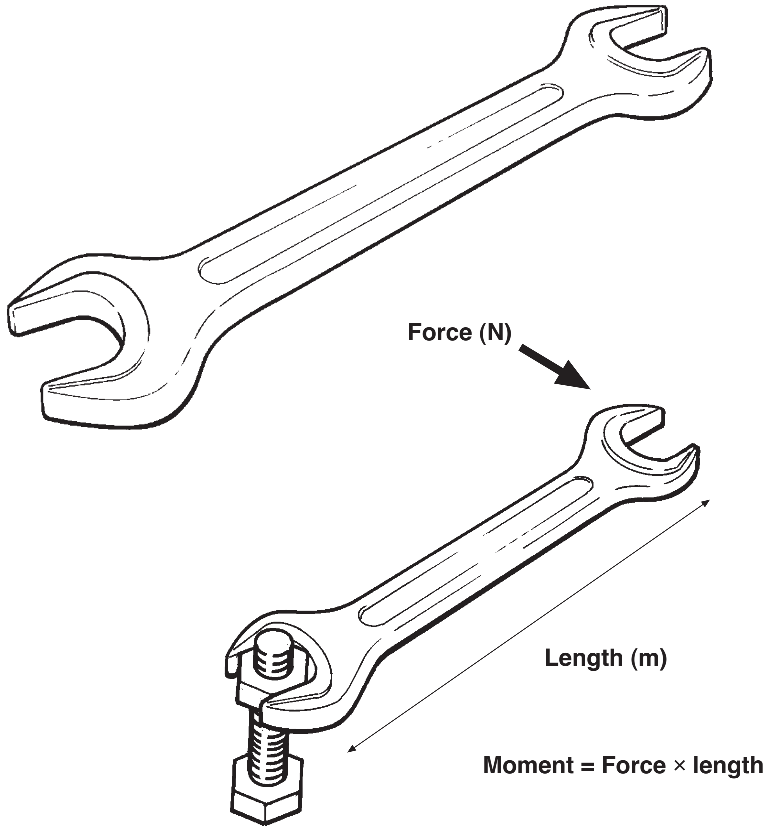
You may wish to do some research here into ergonomic considerations associated with knob and handle design.

(b) the amount of turning force necessary to hold a part of the unit in place.

A commonplace solution is to use a bar, fixed into the screwthread component. This bar may be right angles to the axis of the screwthread, as in the case of a tommy-bar on a woodworking or engineer's vice, or drilled at an angle.



The longer the bar, the greater the turning force or **moment** exerted on the screwthread. This principle is true in the design of, for example, spanners. The larger the nut and bolt to be tackled, the longer the spanner required.



This turning force could be calculated by finding the ***moments*** of the force exerted by the person using the unit. Assuming the force exerted on the spanners remains constant (through the muscle power of the user) at 150 Newtons. For a large spanner 200mm (0.2m) long, turning force =

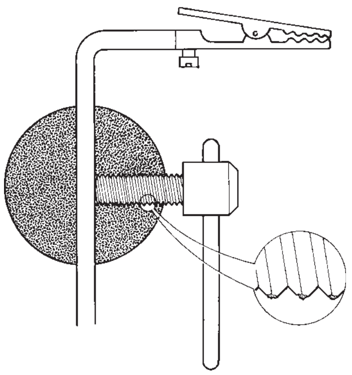
$$150 \times 0.2 = 30Nm$$

For a small spanner 75mm (0.075m) long, turning force =

$$150 \times 0.075 = 11.25Nm$$

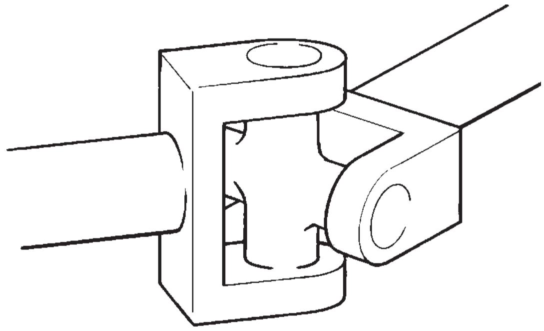
Through the use of a longer lever, it is possible to produce more than **2.5 more turning force** through the application of the same effort on a smaller lever.

It is not necessary in this context to know these forces precisely. It is however an important consideration for you to be aware of in the design of this part of the unit - too much force exerted as the parts of the unit are secured in place runs the risk of 'stripping the thread'.

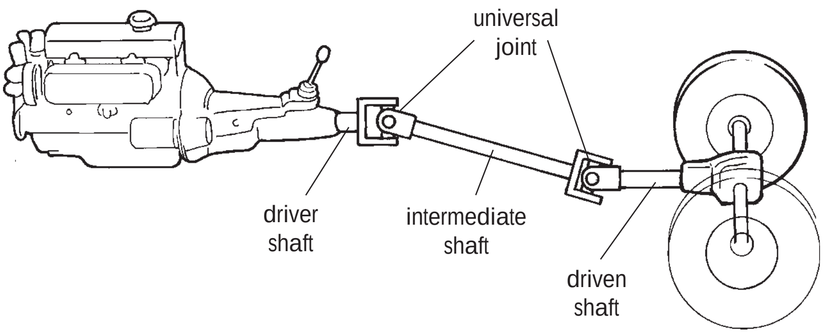


There is little risk of this happening if you intend to use mild steel throughout, for both internal and external threads. There may be a danger where mild steel is used in conjunction with softer materials such as aluminium, or plastics.

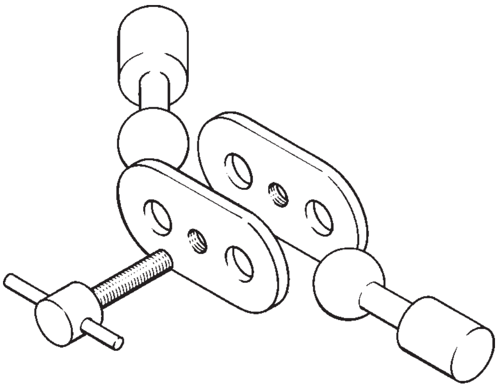
Another approach to the adjustment requirements may be to look for a more versatile, ***universal*** connector. Universal joints (sometimes called Hooke's joints) are used throughout engineering. The most frequent examples are to be found in the motor car, to connect the drive shafts from the engine to the wheels. This form of universal joint is known as a constant velocity joint. Constant velocity (cv) joints are used when the angle is greater than 20 degrees, or there is not sufficient room for a universal joint.



Universal joints were also used to connect the output from the gearbox to the road wheels, in the days before front-wheel drive became the most popular configuration for motor cars.



It is not feasible to make an exact copy of a universal joint using the facilities in school or college. It is possible though to consider an alternative design, whilst using the same principles.



If you decide to use this means of adjusting and locking , you will need to manufacture at least two sets of components. If you decide to make your 'helping hand' more versatile, for example, incorporate two sets of grippers, or two grippers together with a magnifying glass, you may need to produce in total of four sets. This raises two questions:

1) how can I make a number of similar components in the most cost- effective way - from the point of view of time taken to manufacture?

There may be other people in your group, working to a similar design. Is there a way you could bring together what you need to manufacture together with their needs? You could produce as part of a team effort.
See Technology Study File 2: 'Concurrent Engineering'

2) how can I make a number of similar components and be sure that the quality of manufacture is high, i.e. that each component is identical from the point of view of dimensional accuracy? What aspects of the manufacturing processes need to be checked to ensure the quality is high?

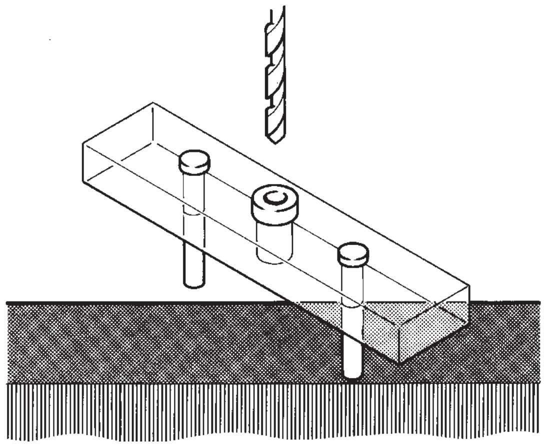
Is it appropriate to consider one person in the group specialising in the manufacture of one particular component? How will you ensure that if someone else makes parts for your design, that they will actually fit?

Manufacturing industry ensures that components are made consistently to the appropriate sizes and standards by using:

1) jigs and fixtures
2) quality control processes

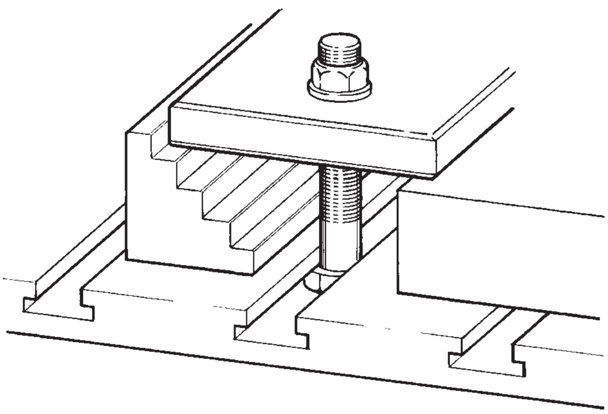
Jigs and fixtures improve accuracy in processing materials by eliminating the need for the worker to measure and lay out exactly where a hole is to be drilled or a material is to be cut.

Jigs: guide the path of a tool on a part being processed. This might be in the form of a centring jig for a hole to be drilled in a piece of timber or metal



centring jig which guides the path of a tool on the part being processed.

Fixtures: attach to a machine and position parts being processed in a specific location on that machine.



Quality control processes ensure that the finished product matches the design in the working drawings. Quality control makes sure that products worked as they were designed. This is achieved by *inspecting parts and products.*

Inspection

Quality must be built in during the manufacture of a product. It cannot be added during inspection. Inspections are not a substitute for accuracy with machine tools or worker performance. Rather, inspections are used to spot problems so that they can be fixed.

Inspection involves measuring a part, comparing the measurement to specifications, and making a decision about the quality of the match. The measurements may be for straightness, flatness, roundness or profile. There are three possible outcomes:

a) accept - acceptable quality means that the part matches the tolerances specified in the working drawings

b) rework - means that the part does not match specifications, but it can be fixed

c) reject - a part is so far from specification that it cannot be reworked, and as such must be scrapped.

There are normally four stages at which the inspection process takes place:

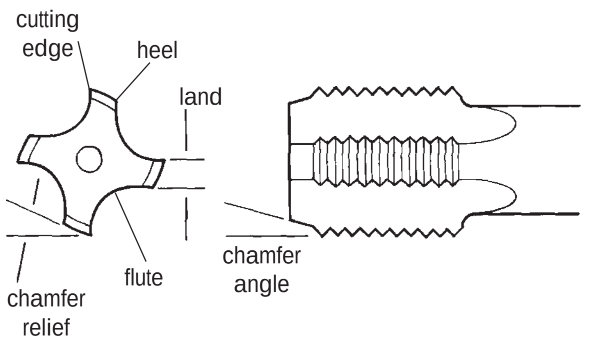
incoming materials; purchased parts, work in progress, finished products

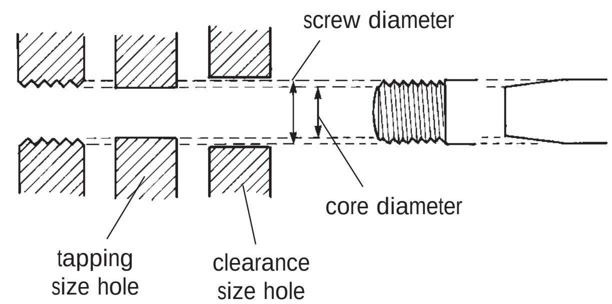
See Technology Study File(s) 3 and 4: 'Quality & Quality Assurance', 'Quality Control: Inspection Techniques'

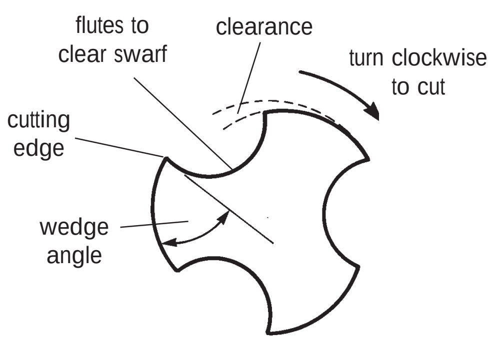
2B. UNIVERSAL CONNECTOR - MAKING THE PARTS

a) side plates **-** What are the key measurements for this pair of components? How could you ensure that both plates are correctly aligned, when the universal joint is assembled? How could you ensure that the semi-circular ends to the plates are easily, yet accurately marked out, cut and finished?

The centre hole for the locking fastener (bolt or machine screw) will need to be threaded. When there is a thread on the inside of a hole, it is said to be ***tapped.*** A hole of a specific size will need to be drilled prior to using the tap to produce the thread.



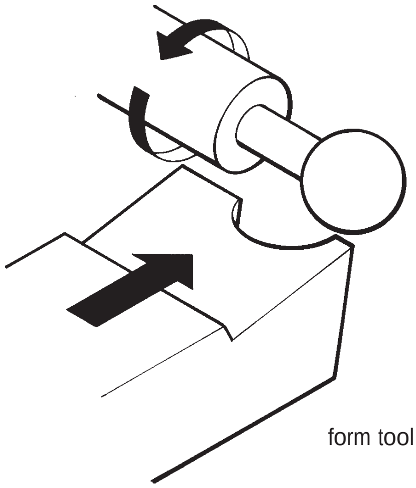




b) ball end - The manufacture of a smooth sphere is essential to the operation of the 'helping hand' unit.

The sphere will need to be turned on a ***centre lathe.***

If you use a conventional machine, then you will need a form tool, ground to the correct shape, in order to machine the profile. You will be given specific help and advice from your tutor on the appropriate use of this cutting tool.

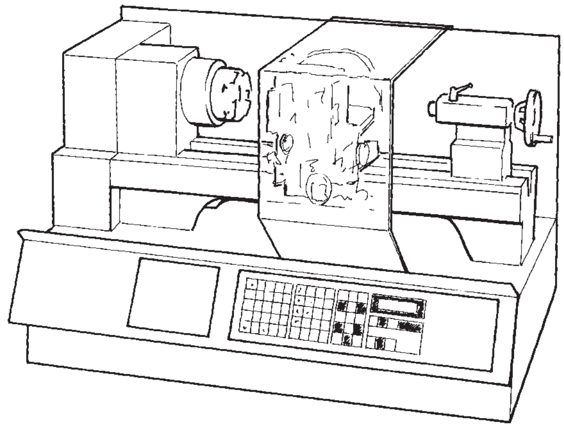


An alternative is to use a CNC (computer-operated, numerically controlled) lathe to produce the profile. Although it may take you some time to write the program to generate this shape, you will find that:

a) the overall machining time is likely to be less than using a conventional machine. Proportionally, the savings are obviously greater the more components you produce,

b) the consistency in the quality of the component is likely to be much higher, than using a standard machine tool.

See Technology Study File 5: 'CNC Machining'



Again, you may wish to consider working with other people in your group, to specialise in the manufacture of specific components for the unit. Consider how this affects the overall manufacturing times. What are the problems when work is 'sub-contracted' out to other people?

EVALUATING YOUR PRODUCT

1. Does the unit meet your original specification for the product? Consider all the points you originally listed.

2. Is it possible to gather some 'expert evaluation' through users of the product other than yourself, or other members of the group

3. How effective is your design in terms of 'design for manufacture and assembly' considerations. If you were proposing to produce a large number of these 'helping hand' units as a commercial manufacturer, what aspects of the design would you need to modify, and why?

4. Is it possible to identify accurately the costs involved in designing, making and assembling your product. How did you arrive at these figures?

   Does this mean that the large scale manufacture of your unit would be a profitable proposition?

5. Does your product meet the appropriate level of quality? If not, what changes due you need to consider during the manufacture and assembly of parts in order for this level to be attained?